EDUCATIONAL OBJECTIVES

Upon completion of this activity, participants will be better able to:

1. Understand the use of neuromuscular blocking agents in the perioperative setting;
2. Describe residual neuromuscular blockade or residual paralysis and the classes of drugs used to manage this phenomenon;
3. List the complications or effects of residual paralysis in postoperative patients;
4. Compare and contrast agents currently used to reverse neuromuscular blockade; and
5. Describe methods used by anesthesia care providers to monitor neuromuscular blockade.

Post-test/Rationale

1. Which of the following are appropriate diagnostic tests for postoperative residual paralysis?

   A. Clinical assessments of neuromuscular blockade focusing on signs such as head lift, leg lift, handgrip, and tidal volume
   B. Subjective monitoring of neuromuscular blockade using visual and/or tactile observation of the response evoked by electrical stimulation of the peripheral motor nerves
   C. Quantitative evaluation of the train-of-four ratio evaluated by assessing the ulnar nerve adductor pollicis muscle through acceleromyography, electromyography, kinemyography, or mechanomyography
   D. All of the above***

Correct answer: D

Neuromuscular function or the degree of residual paralysis can be evaluated in 3 ways: 1) clinical tests that require a patient’s participation and are normally completed when a patient has emerged from anesthesia; 2) visual or tactile evaluation of train-of-four or double burst stimulation at the adductor pollicis; and 3) measurement of the train-of-four ratio with a technique such as acceleromyography, kinemyography, mechanomyography, or electromyography.

2. Which of the following is NOT a potential adverse effect of residual paralysis?

   A. Muscle weakness
   B. Respiratory complications
   C. Malignant hyperthermia***
   D. Abnormal swallowing

Correct answer: C
Patients who experience residual neuromuscular blockade or residual paralysis may develop oxygen desaturation, pulmonary collapse, abnormal swallowing, and an increased risk for aspiration and pneumonia due to lack of muscle recovery. Patients may need tracheal re-intubation, which may delay discharge. Respiratory failure can result from residual paralysis and potentially lead to severe symptoms such as permanent brain damage or death.

3. Absence of residual paralysis is defined as a train-of-four ratio:

   A. Greater than 0.9***
   B. Equal to 0.7
   C. Between 0.8 and 0.9
   D. Less than 0.9

Correct answer: A
Clinically relevant neuromuscular blockade still persists at a train-of-four ratio (TOFR) equal to 0.7. Plaud et al recommended a TOFR of 1.0 or greater. However, most clinicians would agree that a TOFR of 0.9 or higher indicates recovery.

4. Strategies to prevent residual neuromuscular blockade include:

   A. Judicious use of neuromuscular blocking agents
   B. Quantitative monitoring of neuromuscular function
   C. Administration of reversal agents
   D. All of the above***

Correct answer: D
The non-depolarizing neuromuscular blocking agents (NMBAs) should not be given if a procedure can be performed without paralysis. If paralysis is needed, it is important to titrate the NMBA so that no residual effects occur at the end of surgery. The longer the duration of action of the NMBA, the higher the frequency of residual paralysis. NMBAs and anticholinergic reversal agents should be dosed according to monitoring parameters and clinical condition. The newest reversal agent has made titration of the NMBA less important due to ability to rapidly and efficiently reverse the effects of the NMBA. The dosing of this agent (sugammadex) is based on weight and the level of neuromuscular blockade. Many clinicians rely on subjective monitoring parameters, which are not capable of accurately detecting blockade; the provider may over-interpret the exam as full recovery. Quantitative monitoring provides the most accurate assessment of muscle function.

5. The anesthesia triad contains all of the following conditions EXCEPT:

   A. Immobility
   B. Lack of pain
   C. Hypnosis
D. Antibiotic prophylaxis***

Correct answer: D
The triad of anesthesia includes hypnosis, immobility, and lack of pain. Current practice of
general anesthesia includes drugs specific for each component of the triad. Drugs commonly
used for hypnosis are inhalational agents such as propofol or etomidate; analgesics include
fentanyl, remifentanil, and related analgesics; and muscle relaxants are steroidal or
benzylisoquinolinium neuromuscular blocking agents.

6. The anticholinesterase agents currently used in clinical practice for reversal of
neuromuscular blockade have undesirable effect(s)/characteristic(s) including:

A. Need for antimuscarinic agents to counteract side effects
B. Slow onset of action
C. Ceiling effect
D. All of the above***

Correct answer: D
Anticholinesterase agents have cholinergic effects including bradycardia and increased salivary
and bronchial secretions. The side effects are minimized by concomitant use of antimuscarinic
drugs. At usual does of 0.03 to 0.07 mg/kg, a train-of-four ratio of 0.9 occurs within 10 to 20
minutes of administration of cholinesterase inhibitors. The anticholinesterase agents block the
action of the enzyme acetylcholinesterase, which normally hydrolyzes acetylcholine at the
neuromuscular junction. The efficacy of these drugs is limited because their maximum effects
are reached when enzyme inhibition approaches 100%. For example, the ceiling effect is
typically reached for neostigmine at doses of 0.04 to 0.07 mg/kg.

7. Surgeons frequently request neuromuscular blocking agents to achieve the ideal surgical
condition, which includes:

A. Immobilization
B. Large operative space
C. Access to tight spaces
D. All of the above***

Correct answer: D
To allow for a safe surgical procedure, surgeons need a large operative space, particularly when
performing laparoscopic procedures; adequate visualization, which helps prevent intraoperative
complications; access to tight spaces, which can be problematic in gynecologic or urologic
surgeries; and lack of patient movement, which is needed to prevent injuries. These conditions
are interrelated and all are required to achieve an ideal environment during the intraoperative
period.
8. Which of the following is TRUE of sugammadex?

A. The drug is an acetylcholinesterase inhibitor
B. The drug produces cholinergic side effects
**C. The drug can reverse a deep neuromuscular blockade within 3 minutes***
D. The drug reverses all neuromuscular blocking agents

Correct answer: C

Sugammadex is the first of the cyclodextrins to be used as a therapeutic agent. It comprises 8 sugars arranged in a ring; the center of the ring binds steroidal neuromuscular blocking agents (NMBAs) (i.e., rocuronium or vecuronium). Sugammadex quickly, effectively, and safely reverses neuromuscular blockade from the steroidal NMBAs by encapsulating the agents. Sugammadex does not bind benzylisoquinolinium agents (i.e., atracurium or cisatracurium), nor does it bind succinylcholine. Since it is not an acetylcholinesterase inhibitor like other reversal agents, sugammadex does not exert action at the nicotinic or muscarinic receptor sites; therefore, sugammadex lacks the muscarinic side effects of bradycardia and bronchoconstriction. Sugammadex’s unique mechanism of action of encapsulating unbound drug provides adequate reversal without adverse autonomic side effects. Therefore, no antimuscarinic agents need to be administered with sugammadex.

9. Sugammadex’s mechanism of action does NOT involve:

A. Drug action at the nicotinic receptor sites***
B. Creation of a concentration gradient of the neuromuscular blocking agent (NOMBA)
C. Encapsulation of a steroidal NMBA
D. Hydrophobic interactions that trap drugs into the cyclodextrin cavity

Correct answer: A

Since it is not an acetylcholinesterase inhibitor, sugammadex does not exert action at the nicotinic or muscarinic receptor sites. Sugammadex quickly, effectively, and safely reverses neuromuscular blockade from the steroidal NMBAs by encapsulating the agents. Sugammadex holds the NMBA in place with polar side chains attached to the 8-sugar ring. The structure of sugammadex has a hydrophobic cavity and a hydrophilic exterior: the hydrophobic interactions trap the drug into the cyclodextrin cavity, which results in a water-soluble guest-host complex. The binding of rocuronium or vecuronium to sugammadex in the plasma leads to a decrease in free (unbound) rocuronium or vecuronium, which causes a concentration gradient of the NMBA between the neuromuscular junction and the plasma and produces a lower degree of neuromuscular block.

10. Sugammadex dosing is based on:

A. Fixed dose
B. Adjusted body weight
C. Body surface area
**D. Total body weight and level of neuromuscular blockade to be reversed***
Correct answer: D
A sugammadex dose of 2 mg/kg is recommended if spontaneous recovery has reached the reappearance of the second twitch in response to train-of-four (TOF) stimulation following rocuronium- or vecuronium-induced neuromuscular blockade. For rocuronium and vecuronium, a dose of 4 mg/kg is recommended if spontaneous recovery of the twitch response has reached 1 to 2 post-tetanic counts and there are no twitch responses to TOF stimulation following rocuronium- or vecuronium-induced neuromuscular blockade. For rocuronium-induced blockade only, a dose of 16 mg/kg is recommended if there is a clinical need to reverse neuromuscular blockade quickly (e.g., within approximately 3 minutes) after administration of a single dose of 1.2 mg/kg of rocuronium. The efficacy of the 16-mg/kg dose following administration of vecuronium has not been studied.